

LOW POLLUTING EMISSION GAS BURNER

The present invention relates to a gas burner, in particular a burner with low polluting emissions of nitrogen oxides.

It is common practice, in the case of combustion chambers operating at high temperatures, to recuperate part of the heat from the combustion fumes by the pre-heating of the combustive air.

The tendency, at present, is to increase the pre-heating temperature in order to increase the efficiency of the oven.

This objective is opposed by the tendency of an increase in the polluting emissions of NO_x, which is known to be a function of the maximum flame temperature.

Furthermore, it is necessary to reduce polluting emissions as much as possible, as the limits of the NO_x concentration in the fumes discharged, which burner manufacturers must guarantee in order to comply with national and international regulations, are continuously decreasing, mainly as a result of USA market requests.

Emissions lower than 100 ppm are currently required and it is predicted that in the near future their values will have to range from 20-30 ppm even in

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the presence of air pre-heated to 500°C.

To achieve this objective, resort has been made in the last few years to "diluted combustion" and, more recently, to flameless combustion.

5 In order to be able to operate according to the above combustion regime, it is necessary to have an operating temperature permanently above the self-ignition temperature of the combustible material, which, in the case of natural gas, is about 850°C.

10 It is therefore generally necessary to have a burner equipped with a "pilot" i.e. a device capable of pre-heating the oven to that temperature.

A specific characteristic of flameless burners is the capacity of providing a particularly uniform heat
15 flow and temperature profile in the combustion chamber, which is certainly advantageous for heating and thermal treatment ovens.

The burner, however, on which the behaviour of the oven generally depends and especially for plants
20 running in continuous, must allow a wide flexibility in terms of charge regulation (turn-down) and thermal profile.

It is well known that in combustion systems (burners) used in industrial ovens where a combustible
25 gas reacts with the oxygen present in the combustion

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air, the NOx emissions are almost entirely due to thermal NOx whose formation is influenced both by geometrical factors which are characteristic of each single burner, and by operative factors such as air
5 excess, pre-heating temperature of the combustion air and operating temperature of the oven.

It is generally known that, during regime combustion reactions, the production of NOx, in the case of gaseous fuels free of bound nitrogen, is due to
10 the presence of extremely high temperature peaks, caused by a high local concentration of oxygen, due, in turn, to a non-efficient mixing of the combustible matter, the comburent and combustion products.

Possible means for controlling the formation of
15 thermal NOx are traditionally:

stage combustion (of the type "air staging" and "fuel staging") and diluted combustion.

More recently a new technique has been developed, known as flameless combustion, which can be considered
20 as being the evolution of dilute combustion and is technologically based on the recycling of the gas combusted inside the combustion chamber of the oven, obtained by an exasperation of air staging.

This solution, however, has a high cost due to the
25 use of control valves, installed on the feeding line of

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the hot comburent air, adopted for distributing the flow rate of air into the fractions envisaged by the staging.

Burners which currently allow the flame mode to be
5 coupled with the flameless mode, require distribution systems of the comburent air.

A general objective of the present invention is to solve the above-mentioned drawbacks of the known art in a very simple, economical and particularly functional
10 way.

Another objective is to provide a gas burner, capable of maintaining said very low emissions within a wide functioning range, and which is also capable of easily modifying the thermal profile inside the
15 combustion chamber.

In view of the above objectives, according to the present invention, a gas burner has been conceived, with the characteristics expressed in the enclosed claims.

20 The structural and functional characteristics of the present invention and its advantages with respect to the known art will appear clearer and more evident from an examination of the following description, referring to the enclosed drawings, which show a low
25 polluting emission burner produced in accordance with

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the innovative principles of the invention itself.

In the drawings:

- figure 1 shows a raised perspective right-side view, from above, of an embodiment of a gas burner according to the present invention;
- figure 2 is a front view of the gas burner of fig. 1;
- figure 3 is an enlarged detail of figure 2;
- figure 4 is a raised side view of the enlarged detail of figure 3;
- figure 5 is an enlarged detail of figure 2;
- figure 6 is an exploded view of the burner of figure 1;
- figure 7 is a rear perspective view of the burner of figure 1 applied inside an oven;
- figure 8 is a front view of the burner of figure 7;
- figure 9 is a raised left-side view of the burner of figure 1;
- figure 10 is a raised right-side view of the burner of figure 1;
- figure 11 is a raised right-side view of a detail of figure 10;
- figures 12 and 13 are two preferred schematic figures of a first and second burner according

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to the present invention.

With reference to the drawings, the very low polluting emission gas burner in question is indicated, as a whole, by 1, and, in the example illustrated, according to the present invention, it comprises a main hollow cylindrical metal body 6, internally lined with a coating 4 of refractory material, a single duct 8 for the adduction of pre-heated air, an inner central lance 11 for the injection of a combustible gas, at least two outer side lances 10 for the injection of the combustible gas, a set of refractory elements indicated, as a whole, with 30, and a series of nozzles 20 for the injection of the pre-heated air into the combustion chamber of the oven.

15 The main hollow cylindrical metal body 6 has a side surface to which the duct 8, for the adduction of the pre-heated air, is connected.

Said main metal body 6 also contains an insulating fibre 3.

20 Said metal body 6 is open at a first base end, whereas at a second base end it has a housing for a gas distributor 14.

"Plenum" means the volume inside the coating 4, made of refractory material to protect the main metal body 6; said internal volume has the function of making

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the air stream uniform before it passes through the holes situated in the refractory elements, subsequently indicated with 31 and 32.

The burner in question can function both as a pilot in the "flame" mode (i.e. it can heat an oven to the desired temperature) and in "flameless" mode, with very low emissions of nitrogen oxides.

Said burner 1 also includes a series of calibrated drawing holes 16 for the pre-heated air, a housing 17 for a pilot device for the ignition of the burner 1 and a housing 18 for a flame detector.

Said housings 17 and 18 communicate with housings obtained in the metal portion, marked with 12 and 13, respectively.

Said housings 12 and 13 provide the mechanical support for the correct positioning of the ignition device and flame detector of the burner 1, respectively.

Said series of nozzles 20 for the injection of pre-heated air, preferably comprises ten nozzles, and preferably said series of calibrated drawing holes 16 includes three holes.

The refractory unit 30 is topologically divided, for a simpler identification, into three regions: a first region 31, a second region 32 and a third region

33, all concentric.

The first region 31 includes a cavity 34 which communicates with the plenum and with the combustion chamber of the oven, the series of calibrated drawing
5 holes 16, the housing 17 for the ignition device of the burner 1, the housing 18 for the flame detector, and a central hole 19 from which the gas flows out and from which, optionally, the calibrated drawing of the air is effected, to cool the central lance 11 of the
10 combustible.

The cavity 34 is in a rear position with respect to the base surface of the second region 32 of the refractory unit 30, which gives onto the combustion chamber of the oven.

15 Said second region 32 comprises the series of nozzles 20 for the injection of the pre-heated air into the combustion chamber of the oven, situated on the base surface of the same.

The region 32 is of an annular form and lies
20 between the inner first region 31, and the outer third region 33.

Said third region 33, more external with respect to the second region 32, also has an annular form and lies between the region 32 and the external limit of
25 refractory cones which connect the inner wall of the

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combustion chamber of the burner 1.

The third region 33 is made of refractory ashlar
50 and also comprises at least two pass-through holes
21 obtained on a base surface of the same, from which
5 the gas flows, through said at least two outer lances
10, inside the combustion chamber.

The base surface of the second region 32 and the
base surface of the third region 33 of the refractory
unit 30, are preferably level and aligned.

10 Furthermore, the base surface of the second
region 32 and the base surface of the third region 33
of the refractory unit 30 are preferably aligned with
an internal wall 70 of the oven.

A certain quantity of preheated air necessary for
15 the functioning of the burner in "pilot" mode, is drawn
through the series of calibrated holes 16. In order to
limit overheating of the terminal part of the inner
lance 11, an air drawing section is optionally present
between the central hole 19 and the central lance 11.

20 A region 119 is thus defined as the free section
(annular crown) obtained from the difference between
the surface of the central hole 19 housing the gas
lance and the surface enclosed by the external diameter
of the lance 11.

25 Once the k ratio has been defined between the

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hydraulic diameter of the central hole 19 housing the gas lance and the outer diameter of the lance 11, said k ratio ranges from 0.3 to 3; said k ratio preferably ranges from 0.5 to 1.5.

5 When it is necessary to use the burner in "pilot" mode, i.e. when the temperature of the combustion chamber of the oven does not reach the self-ignition temperature of the combustible, the burner operates with gas leaving the central lance 11.

10 When the combustion chamber of the oven reaches the self-ignition temperature of the combustible gas in air (i.e., for natural gas about 850°C), it is possible to switch to the flameless mode: by operating with activation means on the control system of the
15 combustible gas, this is injected through said at least two external side lances 10 of the gas at a rate ranging from 20 to 150 m/s.

The preheated air entering from the duct 8 is accelerated through the series of nozzles 20, the
20 calibrated holes 16 and optionally through the region 119 and reaches rates ranging from 50 to 200 m/s in relation to the preheating temperature of the air itself.

Said preheated air then enters the combustion
25 chamber of the oven.

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The gas burner 1 is capable of functioning both in the so-called flame mode and in the flameless mode, without the necessity of installing costly hot air distribution systems, inside or outside the burner
5 itself.

According to the present invention, in fact, once the thermal power supplied by the burner 1 has been established, it is possible to pass continuously from one mode to the other by simply varying the
10 distribution percentage of the combustible fluid between the central inner lance 11 and said at least two external side lances 10 of the combustible gas, by simply acting on the distribution and control system of the combustible (comprising one or more valves,
15 actuators, transmitters, etc.) without having to modify in any way the supply of comburent air.

By acting on the distribution system of the combustible fluid, it is therefore possible to obtain, by the introduction of preheated air through the series
20 of nozzles 20, the series of calibrated holes 16 and preferably also through the region 119, a homogeneous atmosphere in which there is a mixing between combustible gas, preheated air and combusted gases so that the combustion reaction takes place in a diluted
25 manner without the formation of a flame front.

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In the mixing area of the gas with the comburent and combustion products, already upstream of the reaction, there is a reduced oxygen content, lower than atmospheric level. The limitation of the oxygen concentration allows the reaction to be developed in a greater volume. This enables the reaction to take place between more diluted reagents and it consequently develops more slowly. This limits the formation of temperature peaks, in correspondence with which the formation of nitrogen oxides (thermal NOx) would be favoured.

A known percentage of preheated air is drawn in the cavity 34 through the series of calibrated nozzles in a percentage within the range of 0 to 30% with respect to the total amount of air fed to the burner, which ensures the necessary flow-rate of oxidant for a complete combustion reaction and recycling of the combusted gases.

During the pilot (or flame) functioning mode, the combustible gas is injected into the combustion chamber by means of the central inner lance 11 alone.

In the flameless mode, the gas can be injected:

- parallelly with the preheated air flow

or

- it can be injected so that the jets of combustible

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gas and preheated air meet at a pre-established distance or

- it can be injected so that the jets of combustible gas and preheated air do not meet geometrically
5 (divergent outer lances 10).

Thanks to the strong impulse of the jets of air leaving the series of nozzles 20, the series of calibrated holes 16 and possibly the injection region 119, the air itself and the gas mix with the combusted
10 gases allowing a diluted combustion in the whole volume of the combustion chamber of the oven.

It is possible for the burner to function with gas injected either through the central inner lance 11 or through said at least two external side lances 10.

15 The variation in the percentage of gas distributed by the control valve, between the inner lance 11 and said at least two outer lances 10, allows the regulation of the thermal profile inside the combustion chamber and, as already mentioned, allows continuous
20 passage from the flame functioning mode to the flameless functioning mode.

The gas is injected through the side lances with an inclination angle of the jet ranging from -10° to 10° with respect to the injection axis of the central
25 inner lance 11 of the combustible gas.

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The distribution percentage of the gas through said at least two lances 10 ranges from 0%, in the flame mode, to 100%, in the flameless mode.

The cavity 34 preferably has an outer diameter Da2
5 and a length La1, and an internal diameter Da1.

The shape of the series of calibrated holes 16 does not necessarily have to be circular.

The overall outflow section of the hot comburent air from the region 31 is identified as Ai.

10 Once a ratio s has been defined between the depth La1 of the cavity 34 and the internal diameter Da1 of the same, said ratio s ranges from 0 to 5; said ratio s preferably ranges from 0 to 1.5.

The outer diameter Da2, moreover, is greater than
15 or equal to the internal diameter Da1.

Once the ratio x has been defined, equal to the distance between the barycentre of a first hole of the series of calibrated holes 16 and the barycentre of a second hole of the series of calibrated holes 16,
20 divided by a minimum diameter selected from a hydraulic diameter of the first hole and a hydraulic diameter of the second hole, said ratio x is at least equal to 1.

Said ratio x is preferably at least equal to 2.

The section of each nozzle of the series of
25 nozzles 20 also does not necessarily have to be

circular.

The overall outflow section of the hot comburent air from the second region 32 is identified as Ae.

The total outflow section Ai of air from the
5 series of calibrated holes 16 with respect to the total outflow section Ae of air from the series of nozzles 20 has a ratio ranging from 0.01 to 0.9; it preferably has a ratio ranging from 0.05 to 0.5.

Once the ratio y has been defined, equal to the
10 distance between the barycentre of a first nozzle of the series of nozzles 20 and the barycentre of a second nozzle of the series of nozzles 20, divided by a minimum diameter selected from an internal hydraulic diameter of the first nozzle and an internal hydraulic
15 diameter of the second nozzle, said ratio y ranges from 1 to 10.

Said ratio y preferably ranges from 2 to 5.

Once a ratio z has been defined, equal to the distance between the barycentre of a hole of said at
20 least two holes 21 and the barycentre of a nozzle of said series of nozzles 20, divided by a minimum diameter selected from a hydraulic diameter of the hole and an internal hydraulic diameter of the nozzle, said ratio z ranges from 1 to 50.

25 Said ratio z preferably ranges from 3 to 30.

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The burner 1 also comprises at least two protections 7 for said at least two external side lances 10, a flange 9 connected to the duct 8 for the adduction of the preheated air, a perforated flange 5
5 for supporting said at least two outer lances 10.

Said at least two side protections 7 for said at least two external side lances 10 for the combustible gas, are applied on the side surface of said main metallic body 6.

10 From what is specified above with reference to the figures, it is evident how a gas burner according to the invention is particularly useful and advantageous. The objective indicated in the preamble of the description has thus been achieved.

15 Figures 12 and 13 indicate a flow-rate valve for the single air duct 8, and one or two valves for the combustible gas, for two preferred, non-limiting embodiments of the present invention, respectively.

The forms of the gas burner of the invention, as
20 also the materials, can naturally differ from what is shown for illustrative and non-limiting purposes in the drawings.

The protection scope of the invention is therefore delimited by the enclosed claims.